Space Weather Technical Forecast

Issued on Thursday, 21 March 2024 at 13:19 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: M-flares likely (R1-R2 Radio blackouts), slight chance of X-flares (R3 blackouts). Chance of G1/Minor Storm intervals from CME arrivals Day 1 (21 Mar).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Activity has been Moderate, with the largest flare an M1.9 peaking at 20/2255 UTC from AR3615 in the southeast. There are currently ten sunspot regions on the visible disc. The regions of most interest are AR3614 in the northeast (likely ex-3590 from the previous rotation which gave three X-flares, including X6.3 the largest of the solar cycle so far), AR3615 in the southeast and AR3618 in the southwest. AR3614 has a large main spot with a clear delta configuration, whereas AR3615 has a number of smaller spots, but is showing a couple of delta regions and has been responsible for most of the observed flare activity. AR3618 has grown rapidly over the past day, and now has multiple spots with penumbra, but flare activity has been minimal so far. The remaining regions currently appear stable or showing slight decay.

No new Earth directed CMEs have been observed in the last 24 hours.

Solar Wind / Geomagnetic Activity: Solar winds as observed by DSCOVR at L1 have been at background levels throughout the last 24 hours, around 330-360 km/s. Density was around average or below at first, but showed an increase to slightly above average around 21/0150UTC at the same time as a step change in speed, due to a weak CME arrival. Interplanetary Magnetic Field (IMF), Bt, was weak at first, but increased to a peak of 15nT with the CME arrival. The north-south component, Bz, varied weakly at first, then more strongly after the CME arrival, between +8 and -11 nT. Phi was largely negative (towards the Sun) at first, but has been largely positive (away from the Sun) since the CME arrival. Geomagnetic activity was Quiet to Unsettled (Kp1-3).

Energetic Particles / Solar Radiation: GOES18 high energy (greater than 10MeV) proton flux is at background levels. High energy electron flux (greater than 2MeV) observed at GOES16 was at background levels. The observed 24-hour fluence was below the Active threshold, with a value at 21/0001 UTC of 1.15e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate activity is likely with a slight chance of becoming High with any isolated X-flares, mostly due to AR3614, AR3615 and AR3618.

Solar Wind / Geomagnetic Activity: A complex filament eruption on 17 Mar saw two possible Earth-directed CMEs. One shock has been observed, but it is unclear which CME was responsible, and therefore if there will be a further shock in the coming hours. A coronal hole fast wind from CH12/- may cause an enhancement later on Day 4 (24 Mar).

Geomagnetic activity is expected to be Unsettled at first, with a chance of Active or G1/Minor Storm intervals (Kp4-5) in association with the CME effects. Effects are then likely to decline into Day 2, becoming largely Quiet for Days 2-4 (22-24 Mar). Towards the end of Day 4 a coronal hole fast wind may connect with Earth, with geomagnetic activity possibly becoming Unsettled-

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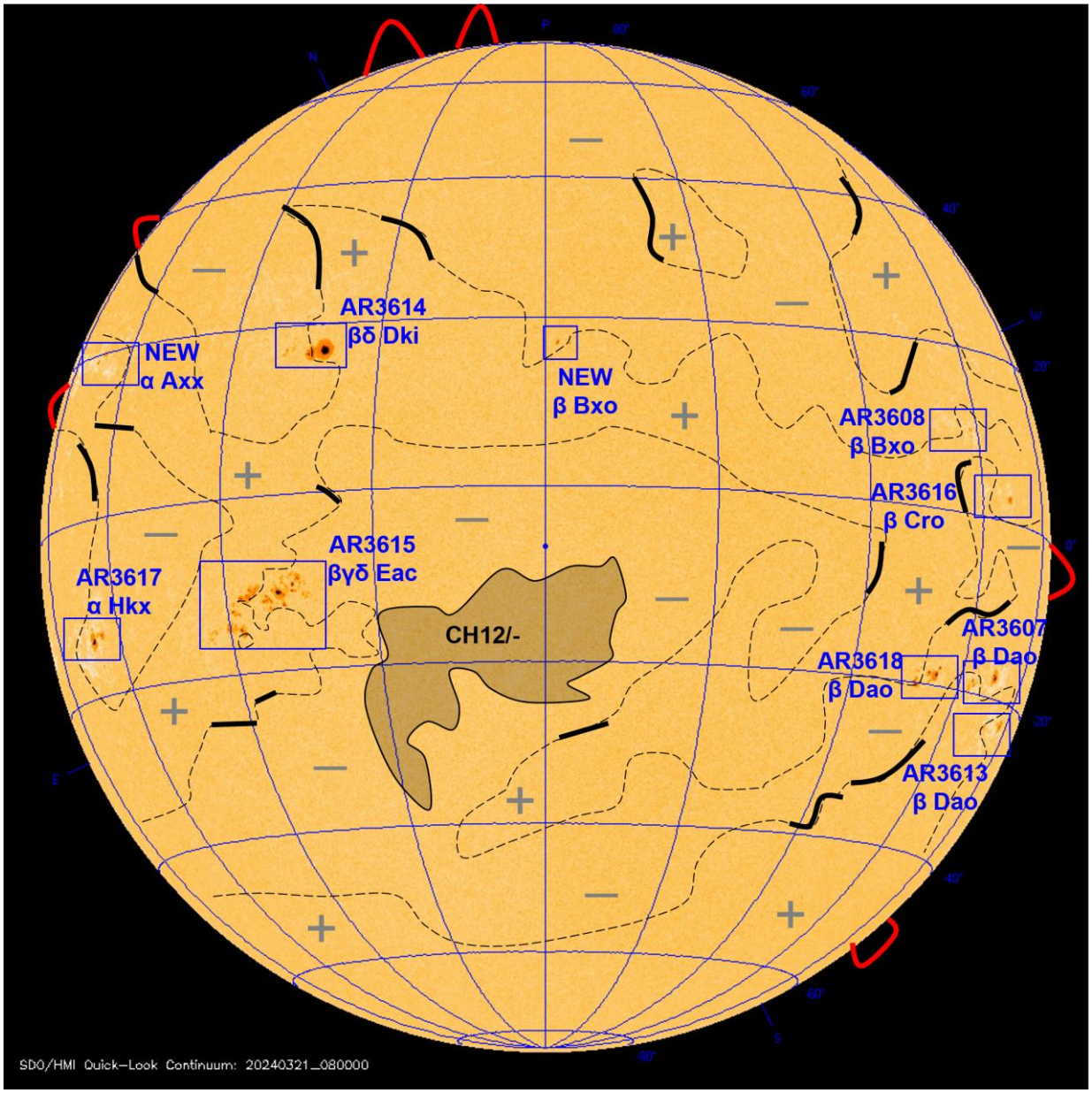
Active (Kp3-4).

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux at GOES18 is expected to remain around background levels, with a slight chance of enhancements. This risk increases slightly through the period as AR3614 and AR3615 rotate towards centre disc. High energy electron flux (greater than 2MeV) is expected to persist at mainly background levels with the associated 24 hour fluence remaining below the Active threshold.

Figure 1. Solar Analysis Valid 21/0800UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A CME was observed from a filament eruption from the southeast disc, occurring near AR3613 at around 17/0230 UTC. This was a complex eruption, splitting into two separate CMEs. The first one went to the southeast, and was faster, narrower but brighter on imagery, possibly giving a glancing impact. The second to the southwest was fainter, slower and wider, and consequently more likely to be observed arriving at Earth. One arrival has been observed, around 21/0150UTC, but it is unknown which of these CMEs has arrived, and if the other has now missed Earth or if it will still be felt. This leads to some uncertainty over the next few hours, but after this no more CMEs are expected to arrive during the forecast period.

Coronal hole CH12/- is located near to centre disc, and may cause an enhancement in solar winds later on Day 4 (24 Mar). On its previous rotation this coronal hole saw solar wind speeds of around 450 km/s, with similar speeds expected once again, however there was little in the way of geomagnetic activity. As we are currently now around the Spring Equinox, negative polarity coronal holes will give more intense geomagnetic activity, so some enhancement is possible this time.

Geomagnetic activity is expected to be Unsettled at first. with a chance of Active or G1/Minor Storm intervals (Kp4-5) early on Day 1 in association with the filament eruption CME from 17 Mar, as well as a very slight chance of G2/Moderate Storm conditions (Kp6). Effects are then likely to decline into Day 2, becoming largely Quiet for Days 2-4 (22-24 Mar). Towards the end of Day 4 a coronal hole fast wind from CH12/- may become effective, with geomagnetic activity possibly becoming Unsettled-Active (Kp3-4).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	40	10	1	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
17/1035	Partial	Filament	SW, near AR3613	505 km/s	Early 21 Mar	May have already arrived, or that may have been preceding glancing blow.

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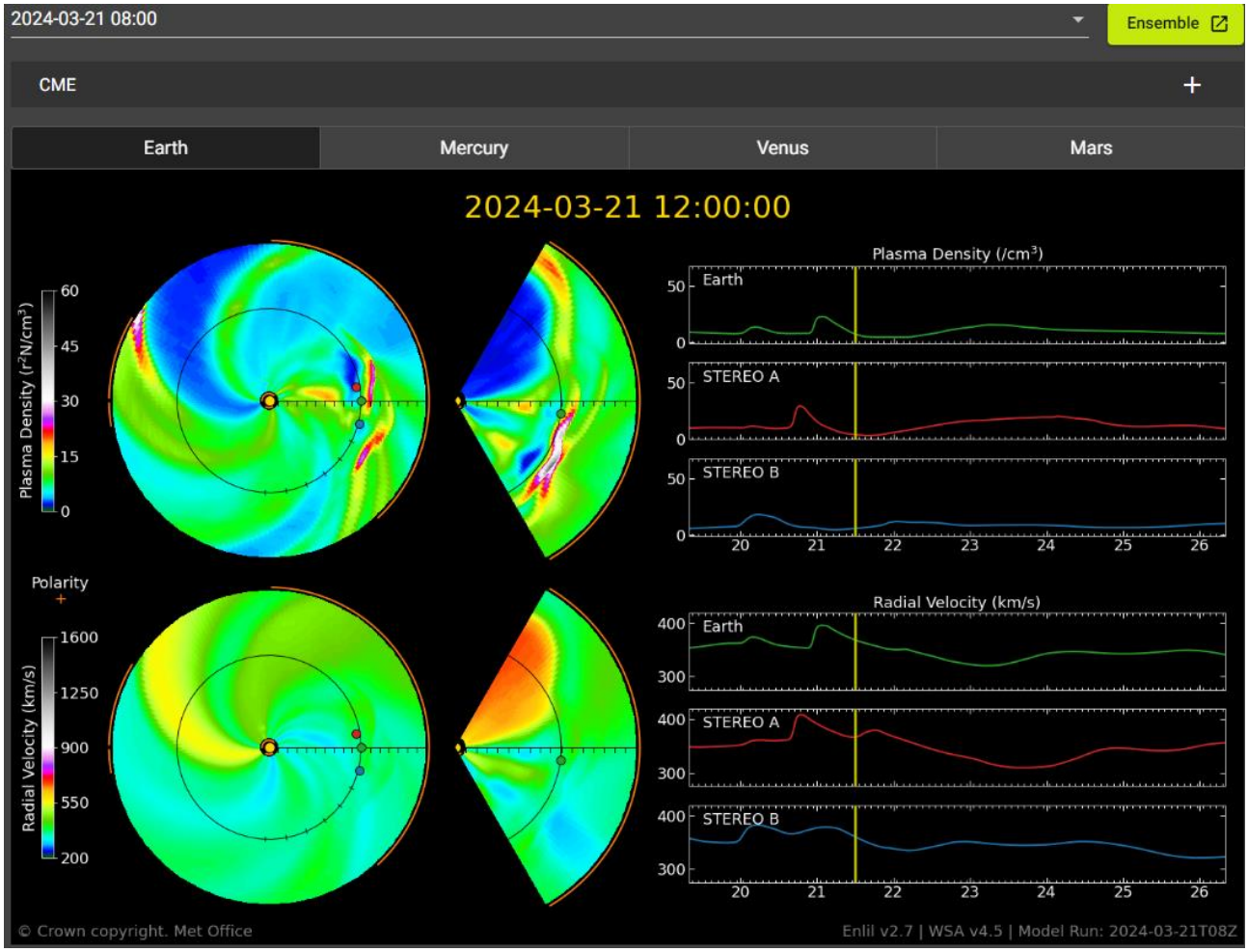
Figure 2: MOSWOC ENLIL, which has CME already past Earth at the current time. Note that ENLIL has very little speed enhancement due to CH12 on Day 4, and faster winds are expected



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Radio Blackouts - X-Ray Flares:

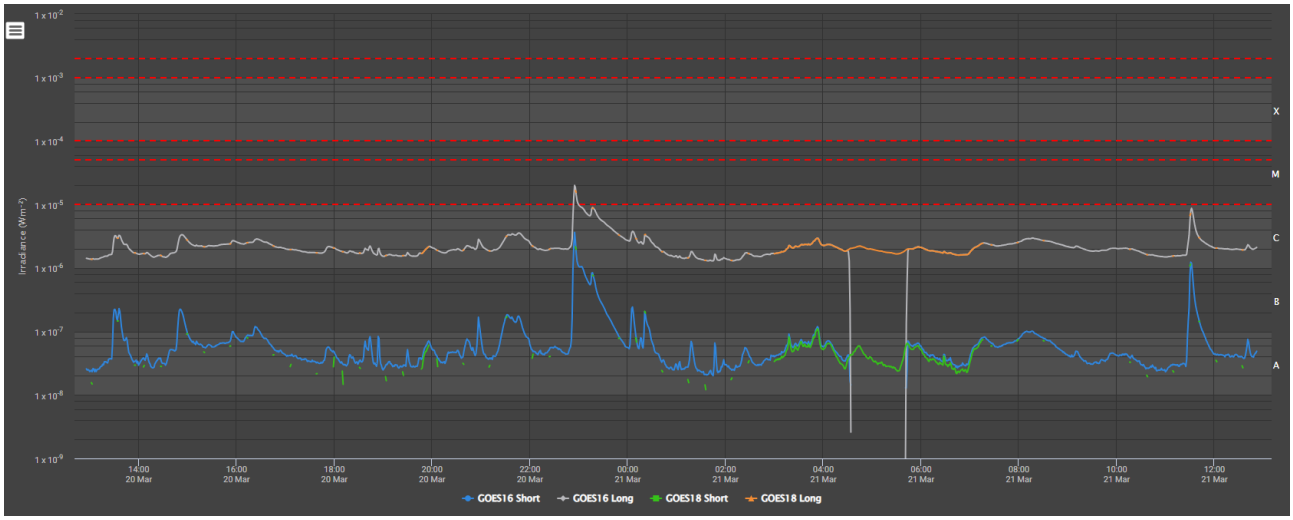
Activity has been Moderate, with the largest flare an M1.9 peaking at 20/2255 UTC from AR3615 in the southeast.

There are currently ten sunspot regions on the visible disc. The regions of most interest are AR3614 in the northeast (likely ex-3590 from the previous rotation which gave three X-flares, including X6.3 the largest of the solar cycle so far), AR3615 in the southeast and AR3618 in the southwest. AR3614 has a large main spot with a clear delta configuration, whereas AR3615 has a number of smaller spots, but is showing a couple of delta regions and has been responsible for most of the observed flare activity. AR3618 has grown rapidly over the past day, and now has multiple spots with penumbra. The remaining regions currently appear stable or showing slight decay.

Moderate activity is considered likely with a slight chance of becoming High from any isolated X-flares, mostly due to AR3614, AR3615 and AR3618.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	60	60	60	60
Very Active	R3 to R5 X Class	No	10	10	10	10

Figure 3: GOES16/18 X-ray flux



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Solar Radiation Storms - (High Energy Protons):

High energy proton flux, as observed by GOES-18 is currently at background levels. Flux is expected to remain at or close to background at first, with further enhancements unlikely. As AR3614 and AR3615 rotate towards centre disc through the period, they move into a slightly better location for proton events to reach Earth and the probability of reaching S1 rises a little.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	10	15	15	15
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

GOES-16 electron flux is expected to remain at mostly background levels. As the CME influence eases a rise in electron flux is possible as the van Allen belts expand back out again, but this is unlikely to be significant.

As a result, the associated 24 fluence is expected to remain below the Active threshold, albeit with a very slight rise in probability through the period. MOSWOC REFM is thought to be giving good guidance.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	5	5	5
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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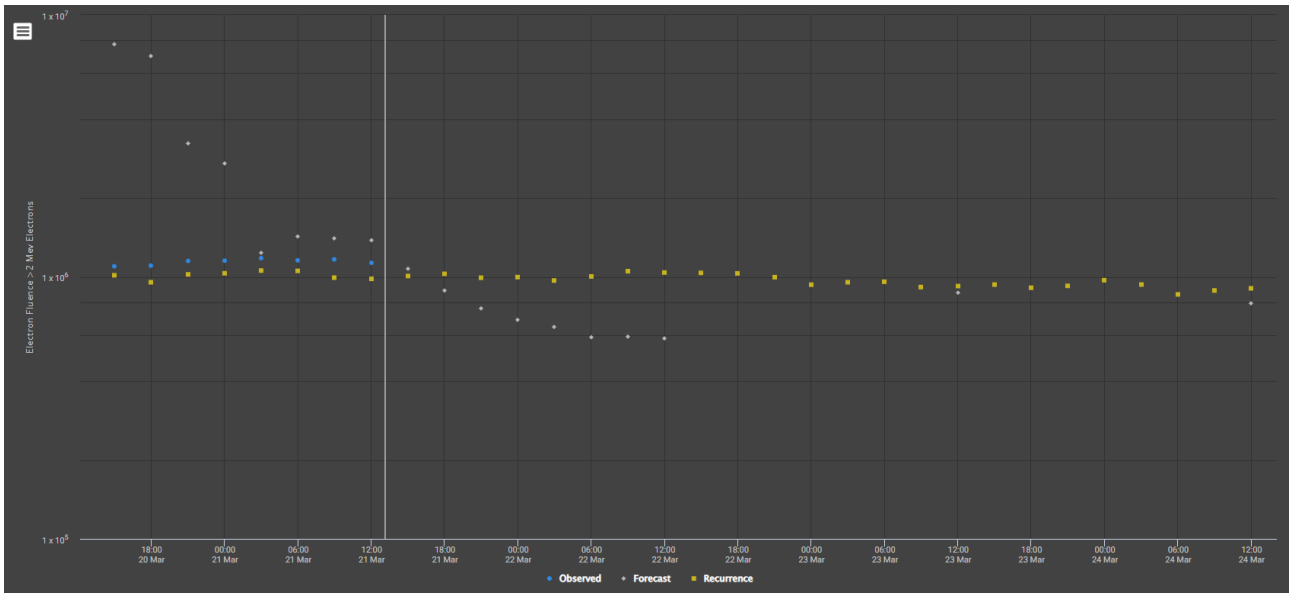
Figure 4: MOSWOC REFM, thought to be giving good guidance.



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